do not appear to be uncommon, although the unique histological structure to which I have alluded has not, to my knowledge, been heretofore pointed out by any one but myself.

I found one small, rugged specimen without label among the late Dr. Bowerbank's collection of sponges; but it appears to have come from the south-west coast of Australia or the Indian Ocean; and although only a fragment (consisting of the remains of two thin fronds united at their base) altogether measuring about 5 × 3 inches, the fibre and dry black-purple sarcode filling up the interstices of the thin lattice-like structure are quite sufficient for identification, while the former, from its large size, here 1-12th inch in diameter at the base of the specimen, seems to ally it to *I. Homei*, Gray; yet, as Dr. Gray states (*l. c.*) that the latter "chiefly differs from *I. basta* in the network appearing to be thicker and stronger," and "is only a young and partly-developed specimen," while *I. basta* has received its designation also from the *coarseness* of its fibre, being like "bast," it may be that future observation will identify the two, which thus differ from the more finely-fibred latticed one, viz. *I. flabelliformis*. The fibre, however, of Dr. Bowerbank's specimen not only appears to be coarser but more oblique in the interstices of its reticulation than that of *I. flabelliformis*, which, on the other hand, is more quadrate. As its histological character will be more particularly mentioned in the "Development of the Fibre in the Spongida" generally, which I propose to consider in the next article, there is no occasion for entering into it more at length here.

The generic description given by Dr. Gray (*loc. cit.* p. 50) may, however, be rendered more complete by adding to it the following histological characters, viz.:—"Sarcode charged with dark purple pigmental cells, especially numerous on the surface and in the horny laminæ of the fibre, which appear to be secreted by them (fig. 12). Core of the fibre granular, grey or colourless, often enclosing foreign bodies, but no pigmental cells."

XIII.—*On the Development of the Fibre in the* Spongida. By H. J. Carter, F.R.S. &c.

[Plate IX.]

For a familiar example of the fibrous structure in the Spongida the sponge, of commerce may be instanced, as consisting of nothing else, all the soft parts having been abstracted, leaving only a resilient mass composed of what will henceforth be called "fibre," while the horny material of which the fibre is chiefly composed will be termed "kerasine" (κέρας), "resembling horn, horny, corneous."

To all who are acquainted with this fibre, it must appear no less true than inexplicable how it can be so formed as in most cases to become axiated or cored with foreign bodies, or by spicules formed by the sponge itself.

Tracing, then, the development of the fibre through the different orders of my proposed classification of the Spongida ("Notes" &c. *loc. cit.*), we find that there is none in the Carnosa (ex. gr. *Halisarca*); that it makes its appearance in the Ceratina (*Luffaria*), where it is composed of horny laminæ axiated by a granular core; that foreign bodies appear within this core in the Psammonemata (*Hircinia*), and in the Rhaphidonemata (ex. gr. *Chalina*) spicules formed by the sponge itself, which are equivalent to the "foreign bodies" in this respect; and so on throughout the other orders, where the spicules are held together by more or less kerasine.

With reference to the presence within the fibre of foreign bodies or spicules developed in the sponge itself, it might at once be assumed that this *must* have preceded the formation of the laminæ of horny material which enclose them, and that these bodies *must* have been placed there by that developmental intelligent power whose existence in every organized product is only known to us by its manifestations.

Our object, however, is not to endeavour to find out what this power is, which may be said to be able to do any thing with every thing and every thing with any thing so far as we can see, but to observe the nature of the material and the sequence of its adaptation in the formation of the fibre.

With this view it is first necessary to briefly define the elementary composition of the material of which the fibrous sponges are composed; and this may be divided into the soft and hard parts—the "soft parts" consisting of a transparent granuliferous substance (polymorphic when alive), in which are suspended nucleated granuliferous cells more or less alike but of different functions, the ampullaceous sacs, the sperm-sacs, and the ova when developed, all together usually called the "sarcode" or "parenchyma" ("syncytium," Häckel*). But of these, the part of most conse-

* How far the whole of this may not be composed of a congeries of polymorphic cells or bodies, and the transparent granuliferous substance itself ('Annals,' 1849, vol. iv. p. 91, pl. xiv. fig. 2, *d d*) a united mass of them, in which their individualization can be no more distinguished than

quence to remember here is the "transparent granuliferous substance" ("sarcodine" and "granula," Häckel), as this is the primordial element of the single ovicell or ovum from which by evolution all the rest is developed; whilst the "hard parts" consist of the grey or colourless granular core (fig. 10, *a*), which may also contain foreign bodies or spicules developed by the sponge itself, according to the species, and of the horny laminæ or kerasine (fig. 10, *b*), which together form the fibre.

Now, if we examine microscopically the fibre of *Luffaria*, the axial structure will be found to consist of the granuliferous core just mentioned, which, being comparatively soft and colourless or of a light *grey* colour, contrasts strongly with the external part, which is horny, concentrically lamellated, and of a transparent brown or *amber* colour. Both these structures are sharply differentiated; and in thin transverse sections the axial one becomes so separated from the horny cylinder that it may be picked out and easily examined under a high magnifying-power (say 450 diameters), when the granuliferous substance of which it is composed closely resembles the "granuliferous transparent substance" of the sarcode, while the granules, which are yellowish and opaque, appear to be spherical (? *cellulæ in embryo*), and become, when dyed with red aniline, much deeper in colour than the rest (Pl. IX. fig. 11, *f*).

Thus the question arises whether the horny layers of the fibre are formed by successive additions to its interior through the granuliferous substance, or whether they are supplied by the sarcode or parenchyma externally.

If we follow the axial substance of the interior, say in the Psammonemata, where the fibre for the most part is cored with foreign bodies, it will be found that the axial substance encloses these bodies, which, indeed, are incorporated with it, and the same with spicules in the Rhaphidonemata &c., so that the granuliferous core might be inferred to exist *before* the horny part of the fibre was supplied; while if we examine the purple sponge (viz. *Ianthella*) to which I have alluded in the concluding part of the preceding article—wherein the nucleated cells of the sarcode, taking on a pigmental action, become strikingly defined by their opaque deep purple colour rendered carmine and translucent by transmitted light

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that of two *Amœbæ* under similar circumstances, future observation must determine. I have already pointed out that the "investing membrane," or dermal sarcode, of *Spongilla*, in which the *pores* are situated, is thus composed ('Annals,' 1857, vol. xx. p. 24, pl. i. figs. 1, *bbb*, 6 & 7).

under the microscope—the horny laminæ may be seen to be almost wholly composed of them in a more or less flattened state, corresponding with the thinness of the lamina in which they are imbedded (figs. 12, *b*, and 14, *b*); while in one specimen, viz. that from Dr. Bowerbank's collection before mentioned, where the cells and their coloured contents have so disappeared as to leave *nothing but their empty cavities*, the horny laminæ present nothing but a reticulated structure of kerasine (tinged with carmine from the escape and diffusion of the colouring-matter), and the axis consists of the colourless or grey granuliferous substance already described. Again, if by taking a very early development of this fibre, in which it is very thin, we lessen the number of the horny laminæ one after another down to the axial granuliferous substance, the *last horny layer* (fig. 13, *b*) will be found to possess comparatively very few pigment-cells, where it rests immediately on the granular core, which, on the other hand, contains none (fig. 13, *a*).

So that, in fact, we are reduced to the conclusion that the horny laminæ were not only deposited on the grey granuliferous axis, but the horny material itself was formed by the *pigmental cells*, which would become substantiated if the horny laminæ generally (that is, in all other sponges) presented this cellular structure in an equally evident degree; but they do not; on the contrary, the higher the magnifying-power that is put upon them in most other sponges but *Ianthella*, the more homogeneous their composition appears to be. Even in the Luffarida and Aplysinida, where the pigment-cells are as purple and as defined as in *Ianthella* itself, there is not a vestige of them to be seen in the horny laminæ.

Thus we are compelled, so far as the *purple* pigmental cells are concerned, to attribute the formation of the horny laminæ either to the grey granuliferous substance of the *axis* on the one side, or to the granuliferous transparent sarcode of the general parenchyma on the other—either to the addition of the laminæ internally from the axis, or externally by some other agency.

Studying the early development of the axial substance, which, being so like the granuliferous transparent portion of the sarcode or parenchyma, can hardly be distinguished from it, in the absence of the horny laminæ, it is not uncommon to find in the Aplysinida *separate* globular horn-cells more or less elongated and branched, arrested on their way to the formation of fibre, and thus rendered abnormal products, in all of which the grey granuliferous material occupies the axis (fig. 1, *g*); so that I have long since termed such bodies "horn-cells" ('Annals,' 1873, vol. ii. p. 6, pl. i. fig. 7, *d d*). Moreover the fibre may present interiorly towards its termination a number of conical lines indicative of a succession of layers arranged after the manner of a bud (*ibid.* 1872, vol. x. p. 107, pl. vii. figs. 5–7), but added to the surface and not produced, as in the vegetable bud, from the axial substance. Hence the horny laminæ would appear to be deposited on the granuliferous axis by the sarcode or parenchyma, although by what element of it in particular there is no evidence to show.

So far, then, we may infer that the axial substance is polymorphic and can enclose extraneous bodies, foreign or formed by the sponge itself, as the case may be, thus supplying the mould or core, and determining, in the first place, the position and extent of the kerasine fibre, which is afterwards deposited on it by the sarcode or parenchyma to complete the formation of the fibre.

However acceptable this view may be in the main, it should be remembered that the axial substance under the microscope is very like the "transparent granuliferous sarcode" of the sponge generally, and therefore that it may possess the means of covering itself with a layer of kerasine in the first instance, although the sarcode of the sponge generally may supply the subsequent ones, since in many of the Hydroida the horny sheath *must* be formed by the *core*, for there is no other soft substance externally, although where there is a fleshy layer externally, as in *Hydractinia*, the horny structure produced by the "horn-cells" in the first instance may be subsequently thickened by it ('Annals,' 1880, vol. v. p. 455).

I have stated that the horny laminæ of sponge-fibre *generally* do not present a vestige of cell-structure; and in no instance, except *Ianthella*, are they composed of *coloured* pigmental cells; but I have also noticed in my description of *Aplysina fusca* (antè) that, when viewed on their edges in a transverse section, the horny laminæ *here do* present a faint *colourless* appearance of cellular structure, especially in the outer layers, which seem to lose it and become more homogeneous as they become older or more internal, evidencing, as in the specimen of *Ianthella* from Dr. Bowerbank's collection, that it is formed by cells which in the fully-formed laminæ are obliterated; while if this be the case generally, then it may be inferred that the horny laminæ are produced from horn-secreting cells in the parenchyma. Where the pigmental cells of *Ianthella* are empty, as in the instance to which I have just alluded, the cellular structure of the fibre is manifest; but it is still, as before stated, tinged of a carmine colour by the pigment having passed into the kerasine. The faint lineation of the colourless cellular structure in the fibre of *Aplysina fusca* (fig. 11, *b*, *c*), although too indistinct for representation, nevertheless presents somewhat of the appearance in form of that of *Ianthella* in the transverse section (fig. 14, *b*). I should also mention that in the abortive (?) horn-cells of *Aplysina purpurea* many of the granules of the axial substance often present a dark purple colour like those of the pigmental cell, and that, in size, the smallest horn-cell hardly exceeds the dark pigmental cell itself (fig. 1, *f*), in which, too, the dark purple granules are most distinct; so that it seems as though the horn-cell originated in the pigmental one; and yet there are no *dark-purple* pigmental cells to be seen in the horny fibre of *A. purpurea* as in *Ianthella*, although the sarcode of the former is equally charged with them (see a description of the pigmental cell, *antè*, p. 104).

As the spicules formed by the sponge itself have been mentioned among the "hard parts" of which the skeletal structure is composed, it may not be without interest to add here that they appear to be developed in a similar way, although certainly, in some instances at least, first originated in nucleated cells and then ejected into the sarcode or parenchyma for completion ('Annals,' 1874, vol. xiv. p. 100, pl. x. figs. 3–15, and pl. xxi. figs. 26, 27); also that, occasionally, arrested spherical, elliptical, and elongated forms of the spicule are present analogous to the "horn-cells" above mentioned (fig. 15). This is particularly the case in a specimen of *Dictyocylindrus laciniatus* from the Mauritius, to which I have before alluded ('Annals,' 1879, vol. iii. p. 297), as it is with the "horn-cells" in the specimen of *Aplysina purpurea* from Trincomalee. Further, it may be observed that the *ornamental* parts of the spicule are the last parts added to its structure (*ex. gr.* the small spines on the anchoring-spicule of *Hyalonema*, 'Annals,' 1873, vol. xii. p. 371, pl. xiv. fig. 9, *f*, &c.), and that the horny fibre is frequently accompanied by a foreign body attached to its surface by an extension over it of the last formed horny lamina, indicating in either instance that the sarcode or parenchyma, at least, has the power of producing both substances ('Annals,' 1872, vol. x. pl. vii. fig. 4, *f*).

Analogous, however, as the sequential growth of the fibre and the spicule in the sponges may be, they are not homologous, any more than the bones and ligaments in the higher animals; and but for a single instance, viz. that published in 1865 by Fritz Müller in *Darwinella aurea* (Archiv f. mikroskop. Anatomie, Bd. i. p. 344, Taf. xxi.), wherein some of the fibre has a stellate or rayed form, there is not another recorded instance in which there is the slightest resemblance of the horny fibre to the thousand and one known forms of spicules which exist among the sponges. And even here Fritz Müller's "favourite" hypothesis (*loc. cit.* p. 351), viz. that in evolutionary development a horny form of the sponge-spicule precedes the siliceous and calcareous ones, is not borne out by the facts that in the first order, viz. the Carnosa (according to my classification), the first family, viz. the Halisarcida, possesses neither fibre nor spicules, that the second family, viz. the Gumminida, possesses spicules but no fibre, and that it is not until we reach the Ceratina and other orders that the *fibre* is developed. So with the development of the sponge from the ovule, the spicules of the species are already seen in the embryo, while the fibre does not appear until the embryo has become fully developed into the young sponge ('Annals,' 1874, vol. xiv. pls. xxi. and xxii. fig. 34, respectively).

Again, if I am right as to the sequential way in which the fibre and the spicule are formed, the core or axis receives in the one as well as in the other its respective coverings *at once*, and not by transition; that is, the kerasine alone is deposited in the former and kerasine suspending silex in the latter. Thus Schmidt's statement, in 1866, that the siliceous spicule, when deprived of its silex by fluoric acid, leaves a horny form ("Hornnadel," Spong. Adriatisch. Meeres, 2nd Suppl. p. 21), by no means confirms Fritz Müller's hypothesis, as was intended, which, in an evolutionary point of view, as before shown, is not substantiated by either phylogenetic or ontogenetic development.

Moreover I have studied *Darwinella aurea* myself independently, as my naming a specimen *Aplysina corneostellata*, which came from the N.W. coast of Spain, will show, and find that to identify the stellate development of the fibre with the spicules ("Nadeln") of a sponge requires a stretch of imagination which the anatomical facts, forms, and measurements that I have long since published ('Annals,' 1872, vol. x. p. 101, pl. vii.) do not justify, any more than the phylogenetic and ontogenetic development to which I have just alluded. Hence I do not think that the term "Hornnadeln" should be applied to this fibro-stellate structure.

I can see no more analogy between the fibre and the spicule than that above mentioned. They are as distinct from each other as the ligamentous structures and bones of the human subject, where, under normal conditions, the former never become the latter nor the latter the former.

Thus, then, my study of the development of the fibre leads me to the inference that the granular core is able to produce a kerasine layer at first, but that subsequent ones are added by some other agent of the sarcode or general parenchyma ; while the kerasine is supplied by the pigment-cells in *Ianthella* simulated by faint cell-structure in *Aplysina purpurea*, but in no other instance that has come under my observation have I been able to see this.

Other facts bearing upon the fibre and the spicule respectively might be mentioned here with advantage, viz. that the interior of a Rhaphidonematous fibre may have the whole of its spicules removed by absorption, and the core so transformed into a simple granuliferous tube, while the horny part still remains unaffected, that it becomes almost identical with the fibre of *Aplysina*, and that, too, while the acerate spicules in the circumferential fibre remain intact, as I have before mentioned (p. 109)—which led to my calling the specimen "*Aplysina chalinoides.*"

Again, it is not uncommon to find the core-spicules in both the Rhaphidonemata and Echinonemata only *partly* absorbed, although the horny fibre in this case also remains perfectly intact. Here the spicule is often obliterated, all but the central canal and a single fragment of its entire calibre in the centre, whereby it presents the form of a spindle—which at first appears to be a new form, but is subsequently proved, by the presence of others in different degrees of absorption, to be otherwise, and the true form of the spicule thus found out.

Nor is it uncommon to find the central cores of spicules themselves so enlarged that the siliceous portion is more or less reduced to a mere continuous film while its extremities are still *closed.*

All this points out that the spicules within the fibre and the internal part of the spicule itself may undergo absorption without any evident contact with the element by which they may be surrounded.

I have said nothing of the glassy fibre of the vitreous Hexactinellida, because it, *mutatis mutandis*, is the same as the horny fibre ; and, of course, in the Lithistina there is no fibre at all, where its office is supplied by the interlocking of the filigreed extremities of the branches of the spicules.

EXPLANATION OF PLATE IX.

Fig. 1. *Aplysina purpurea*, from Trincomalee. Upper half of the specimen, natural size. *a a*, vents ; *b*, monticular elevation, magnified 2 diameters ; *c*, reticular subdermal structure ; *d*, dermal termination of fibre ; *e*, group of pigmental and horn-cells ; *f*, pigmental cells ; *g*, horn-cells (scale 1-48th to 1-6000th inch) ;

h, fragment of the fibre, lateral view; *i*, the same, transverse section (diagrams).

Fig. 2. The same, from S.W. Australia. Fragment, natural size. *a*, lobule, magnified; *b*, subdermal reticulation; *c*, dermal termination of fibre.

Fig. 3. Pigmental cells of the Ceratina. *a*, dark opaque purple; *b*, light-coloured pinkish brown.

N.B. The opaque purple pigmental cells in this illustration are made *generally* dark for contrast, or as they appear under a low magnifying-power; otherwise their elementary composition is similar to that of the light-coloured pinkish-brown ones, with the exception of the pigment.

Fig. 4. Pigmental cells of *Dysidea fragilis*=*Spongelia*.

Fig. 5. The same, elongated, ? muscular.

Fig. 6. Filaments of the trama in *Chondrilla nucula* and *sacciformis*; ? filiform cells.

Fig. 7. *Spongilla*. Sponge-cells of the parenchyma containing fragments of carmine. *a*, carmine, after Metschnikoff (Zeitschrift f. wiss. Zoologie, Bd. xxxii. Taf. xxi. fig. 4).

Fig. 8. *Stelletta aspera* and *Dercitus niger*, pigmental cells of. *a*, nucleus; *b*, granules.

Fig. 9. *Chondrilla sacciformis*. Pigmental granules, in irregular groups as they occur, viz. without cell-definition.

N.B. Figs. 3–9 inclusive are on the scale of 1-24th to 1-6000th inch.

Fig. 10. *Luffaria*. Fragment of the fibre, to show the relative size of its component elements. *a*, granular axis; *b*, horny laminæ.

Fig. 11. *Aplysina fusca*. Fragment of the fibre, to show the relative size of its component elements. *a*, granular axis, tubular, membranous; *b*, horny laminæ; *c*, transverse section; *d*, granular axis; *e*, horny laminæ; *f*, fragment of granular axis, greatly magnified; *g*, transparent sarcode; *h*, granules.

Fig. 12. *Ianthella*. Fragment of the fibre, lateral view. *a*, granular axis; *b*, horny laminæ, chiefly composed of pigmental cells.

Fig. 13. The same. Fragment of small fibre, lateral view. *a*, granular axis; *b*, first horny lamina bearing a few pigmental cells.

Fig. 14. The same. Transverse section of the fibre, showing the horny laminæ and their pigmental cells edgewise. *a*, granular axis; *b*, horny laminæ.

N.B. Figs. 10–14 inclusively are all diagrams.

Fig. 15. *Dictyocylindrus laciniatus*, Mauritius. *a*, abortive development of the spicule; *b*, cells of the parenchyma. (Scale the same as that of fig. 1, *e*, for analogical contrast.)

XIV.—*On an Organism which Penetrates and Excavates Siliceous Sponge-spicula* (Spongiophagus Carteri). By Prof. P. Martin-Duncan, F.R.S., Pres. Royal Microscop. Soc., &c.

In a communication which I made to the Royal Microscopical Society on June 8, 1881, the presence of green-coloured cells on siliceous sponge-spicula, in relation to minute penetrations into their axial canals, was asserted. The occurrence of a